Test Plan for ECP-0511

Field Test to Reduce Velocity Dealiasing Errors by Using a 2-D Velocity Dealiasing Scheme

1. Introduction and Background

The current Weather Surveillance Radar-1988 Doppler (WSR-88D) utilizes two velocity dealiasing schemes, the Velocity Dealiasing Algorithm (VDA) and the Multiple Pulse Repetition Frequency (PRF) Velocity Dealiasing Algorithm (MPDA). The VDA remains virtually unchanged since the deployment of the legacy WSR-88Ds. The VDA primarily uses radial continuity, an average of nearby velocity neighbors, or an Environmental Wind Table (EWT) to help resolve winds exceeding the maximum unambiguous velocity (Nyquist Velocity, V_N) which for the WSR-88D is between 21 and 35 m s^{-1} for the following precipitation Volume Coverage Patterns (VCPs): VCPs 11, 12, 21, 211, 212, & 221 and the clear air VCP 32. The long-pulse clear air VCP 31 has a Nyquist velocity of about 8 m s^{-1}. While generally reliable, the VDA can fail: 1) under strong shear conditions; 2) in velocity data with moving clutter; 3) in areas with weak echoes; 4) when the Nyquist velocity is much lower than the prevailing winds; or 5) where the values in the EWT are not representative of the local storm winds. The MPDA, fielded in 2004 as VCP 121, takes multiple scans of velocity data at the same elevation using up to three different PRFs. It can dealias velocity with a high degree of reliability where there is more than one velocity estimate available. However, the utility of the MPDA in VCP 121 is limited during rapidly changing weather events because the additional scans required increases the volume scan time to nearly 6 minutes. VCP 121's utility is further diminished because it has only 9 unique elevation angles with which to interrogate storm structure.

The Radar Operations Center (ROC) has been evaluating a two-dimensional velocity dealiasing scheme (VDEAL) that is more robust than the current VDA. It works by simultaneously dealiasing all gates in an elevation scan using a least-squares approach to minimize the discontinuity caused by aliasing. Greater weight is given to velocity differences near zero or at multiples of $2V_N$ as well as velocity differences where the corresponding spectrum width values are low. VDEAL can be used by all VCPs except VCP 121 with no perceptible delay in product availability.

In the ROC study 520 low-level velocity products were evaluated. The VDA had 252 with dealiasing errors while VDEAL had only 71 with dealiasing errors. More striking was the reduction in velocity dealiasing errors and improved data quality of the VDEAL over the VDA in hurricanes. Of 201 velocity products evaluated, VDA had 185 total dealiasing errors while VDEAL had only 5 dealiasing errors. Independent evaluation by scientists at the National Severe Storms Laboratory has shown dramatic improvement of VDEAL over the legacy VDA for VCP 31. These positive results have provided the impetus for conducting a field test during the latter half of 2011.

2. Objectives of Field Test

There are three primary objectives for conducting a field test: a) Obtain field experience with VDEAL at new sites under a broad range of meteorological conditions; b) Gain acceptance of VDEAL from operational users; and 3) Determine if VDEAL can/should replace the legacy VDA for most VCPs or should be made available as an optional dealiasing tool for special circumstances. Such circumstances might include VCP 31 because of its low Nyquist velocity. the phase-coded SZ-2 VCPs 211, 212, and 221 where weak trip echo tends to be noisy, and in large hurricanes where widely spaced spiral bands are not well handled by VDA because the environmental wind table does not contain wind data representative of the winds in the different quadrants of the hurricane.

3. Methodology

a. Operational Sites. Each radar site participating in the field test will receive a mod kit with instructions on how to install a modified version of the velocity dealiasing task that allows activation of the 2-D VDEAL algorithm. Sites will have the option of activating or deactivating the 2-D dealiasing algorithm via a toggle on the RPG Status Control HCI screen. Once per volume the velocity dealiasing task will log to the Status Log a message indicating if the 2-D VDEAL has been invoked. Once invoked, the 2-D algorithm will be used for dealiasing with two exceptions:

   i. VCP 121 will continue to use the Multiple PRF Dealiasing Algorithm (MPDA)

   ii. If a site chooses to sectorize PRFs, velocity dealiasing will revert to the VDA.

b. Radar Operations Center. ROC staff will use two approaches to evaluate the effectiveness of VDEAL. The first method will develop statistics on the frequency with which dealiasing errors occur and the second method will query users on their perception of the efficacy of VDEAL.

   i. Statistics. To generate statistics for the first approach, the Applications Branch will simultaneously run two non-operational RPG platforms for each participating field site. One RPG platform will use VDEAL while the second platform will use the legacy VDA. Members of the Applications Branch and the ECP test team will examine velocity products from both VDA and VDEAL and tabulate the frequency with which errors are observed. Additionally, they will note and tabulate those errors that could cause problems operationally.

   The volume of data generated will likely require test staff to restrict analyses to representative data sets for different types of weather

events from each site. Types of weather will include clear air, stratiform rain, convective storm systems, and hurricanes (where and when possible). A reasonable volume of data for evaluation would be about 100 hours per site. To compute the number of velocity products that will be examined we assume an average of 9 elevation angles per volume scan (averaged over all VCPs) with 11 high resolution velocity products (2 super resolution and 9 non super resolution). We further assume 10 volume scans per hour (averaged over all VCPs). The number of products is further doubled because products from both dealiasing algorithms will be examined. For 8 sites the number of products to be examined is 8 x 2 x 10 x 11 x 100 or 176,000 products. A conservative estimate (based on routine dealiasing screening Bob Lee does for data quality related work) is that 400 products per hour can be tallied yielding an estimate of 440 staff hours. Four people should be able to complete the analyses in a month.

The ROC does not plan to conduct a highly detailed analysis of the severity of the dealiasing errors because that type of analysis has already been done by NSSL scientists and by ROC Applications personnel for limited data sets. Analyses by both organizations have clearly shown VDEAL to have a superior performance over the VDA.

ii. Questionnaires. An on-line questionnaire will be developed to obtain feedback from forecasters at each WFO participating in the field test. In addition to site name, date of completion, and optional forecaster name, users will be asked to indicate if they had received guidance in the use of the 2-D velocity dealiasing algorithm (VDEAL), their perception of velocity dealiasing errors compared to the legacy VDA and anomalies observed, Finally, they will be asked either to recommend or not recommend fielding VDEAL. If they recommend VDEAL be fielded, they will be asked if it should be the primary velocity dealiasing algorithm or be made available as a user selectable option.

4. Success Criteria

Depending on the results of the statistical analyses and the questionnaires, the field test of the 2-D VDEAL may be deemed fully successful, partially successful, or not at all successful. A fully successful outcome would result in a recommendation to replace the VDA with the 2-D VDEAL algorithm except for special circumstances where the VDA is specifically needed. A partially successful outcome would result in a recommendation that the 2-D VDEAL be made available as an alternative dealiasing scheme for special types of weather events. An outcome with no success would cause a recommendation that the 2-D VDEAL undergo further development. For the statistical analyses, the test team will rely on descriptive statistics solely rather than apply a significance test. Based on results of the statistics and the site

questionnaires, the test team will arrive at a consensus expert opinion as to the degree of success.

a. Fully successful. To be considered fully successful, the statistical analyses must show a substantial reduction in velocity dealiasing errors for all types of weather events and all participating sites, via the questionnaires, must recommend it replace the existing VDA.

b. Partially successful. To be considered partially successful, the statistical analyses must show substantial improvement over the VDA in one or more weather categories and have comparable performance to the VDA for the other categories. The responses to the questionnaires from at least one test site must support the use of the 2-D VDEAL algorithm for the same weather category(y)(ies) as the statistics.

c. Not successful. The 2-D VDEAL algorithm will be deemed not successful if its velocity dealiasing error rate is on a par with or worse than the legacy VDA or the field sites indicate no operational benefit to fielding VDEAL.

5. Resources

a. Personnel. The personnel for the field test will consist of the test manager Dave Zittel (Applications Branch), alternate test manager Rich Murnan (Applications Branch), and the ECP test team members. The team includes Ruth Jackson (ECP facilitator), Scott Saul and Amy Daniel (Operations Branch), Dan Purcell (Documentation), Cynthia Chrisman (Documentation), Steve Smith and Zack Jing (Software Engineering), and Patrick Quigley (System Engineering). Robert Lee (Applications Branch) and one or more students in the Applications Branch may assist with the field test.

The roles for the test team members are as follows:

i. Dave Zittel, Test Manager. Has overall responsibility for the conduct of the test, for data analysis, and presentation of results. Also, he will coordinate with Tim Crum to solicit participation by field sites.

ii. Rich Murnan, Alternate Test Manager. Serves as the backup when the test director is unavailable. Murnan will also help develop the web-based questionnaire to be completed by the field sites.

iii. Ruth Jackson, ECP facilitator. Assists the test manager in completing the necessary documentation through the duration of the ECP.

iv. Dan Purcell, Documentation. Ensures software modification kits for activating the 2-D VDEAL algorithm work as expected.

v. Steve Smith, Software Engineering. Ensures changes to the velocity dealiasing task to invoke the 2-D velocity dealiasing task are submitted in a timely manner for Build 12.2; works with source scientist, Zack Jing, to ensure the 2-D VDEAL algorithm will not negatively impact operation of the WSR-88D not related to velocity dealiasing and subsequent algorithms dependent on velocity data (e.g., cause RPG task failures or require a restart of RPG software).

vi. Test team members. Assist the test manager in defining the objectives of the field test, identifying the types of weather to be evaluated, determining the optimal method for activating the VDEAL algorithm, developing questions for the site questionnaire, developing statistics, coordinating with field sites, writing the test plan and final report, and preparing materials for presentations to the Technical Advisory Committee (TAC) and the Software Recommendation and Evaluation Committee (SREC).

b. Equipment

i. Hardware

1. Field Sites. The field test will require full thread WSR-88Ds at the operational sites. Sites will also need to have access to the Internet World-Wide Web in order to complete on-line questionnaires.

2. Applications Branch. The Applications Branch has 7 Linux work stations capable of supporting Build 12.2 software. Each work station can have up to 10 non-operational RPGs installed on them. Personal computers will be used to run software to view and log velocity dealiasing errors.

ii. Software

1. Operational RPG software. Each participating field site will need Build 12.2 RPG software.
2. Non-operational RPG software at the ROC. 16 unique versions – 2 per site
3. Zoomerang – Online web-based questionnaire software
4. Hummingbird Exceed on PCs
5. Microsoft Excel spreadsheet software
6. NWS Chat for communicating with field sites

c. Operational Sites – TBD. May depend on deployment schedule for Build 12.2
   i. 4 gulf/Atlantic coastal sites
   ii. 2 mountainous sites

iii. 2 plains sites

6. Schedule and Milestones

a. 3/1/2011 - Make presentation to Interdepartmental Hurricane Conference, Miami, FL – Generate interest in participating in field test
b. 3/8/2011 – Give information briefing to TAC, to proceed to field test
c. 3/1/2011 – 5/1/2011 – Solicit participation from sites
d. 3/15/2011 – Check into Razor changes to VDEAL necessary to conduct field test
e. 4/1/2011 – Complete test plan
f. 5/1/2011 - Complete Concept of Operations for field sites
g. 5/1/2011 – Complete draft of on-line survey questions in Zoomerang
h. 5/1/2011 – Complete site installation instructions for enabling VDEAL
i. 5/15/2011 to 6/1/2011 – Deploy software mod kits
j. 6/1/2011 to 12/1/2011 – Conduct field test
k. 6/1/2011 to 1/15/2011 – Analyze velocity products and tabulate results
l. 2/15/2012 – Complete final report
m. 3/15/2012 – Briefing to TAC either Decision briefing to field or recommend further research

7. Risks

a. Each work station has been shown to support acquisition and archival of data in real time from three different radars when using the legacy VDA. It is not known how many RPGs can run on a work station when the RPG is using the 2-D VDEAL algorithm.

b. The time required to evaluate velocity products may be much greater than anticipated, especially if sites encounter unusual dealiasing issues that require detailed investigations.

c. The weather may not be diverse enough to thoroughly check out the performance of the 2-D VDEAL algorithm.

8. Costs

There are no hardware costs anticipated for this ECP. Eight CDs will be required on which to write the software modification kit. ROC staff time will be required to write documents, develop and test a mod kit, coordinate with field offices, analyze velocity products, and compile results.

9. References

Application of a 2-Dimensional Velocity Dealiasing Algorithm in the WSR-88D Network, Nicholas Langlieb and William Tribout: Senior Capstone project, May 7, 2010, 19 pp

Draft report on the FY 2010 NSSL-ROC MOU Task 3: Velocity Dealiasing Improvement, Arthur Witt: November 20, 2010, unp.

Attachments

Deployment schedule for Build 12.2 – Not yet available